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(54) SOLVENT RECOVERY

(71) We, KORES HOLDING ZUG A.G. a Swiss Body Corporate of Baarerstrasse 57, CH 6300 Zug, Switzerland, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed to be particularly described in and by the following statement:—

The invention relates to a plant for recovering a volatile solvent during the drying of a web coated on one side with one or more materials carried by the solvent.

The term "web" has a very broad meaning and may refer to paper, textiles or foils, e.g., of plastics materials or metals.

Similarly, the term "solvent" is not restricted to organic volatile distributing fluids but covers any volatile liquids, including inorganic liquids and even water if their recovery appears desirable for any reason whatever.

The coating composition used to coat the carrier web need not essentially contain its solid constituents in dissolved form. The plant according to the invention may also be used for drying coating compositions based on dispersions and for the recovery of the distributing fluids required therein.

The term "coating" is applicable to any layer which has been formed continuously and which is applied to a carrier web material pretreated if necessary and which layer is dried by evaporating the distributing fluid.

Hence, a plant according to the invention may form the drying solvent recovery section of a coating plant, in which substances distributed in a volatile distributing fluid condensable by cooling are applied to a carrier web, whereafter the distributing fluid is evaporated by heating so that the coating is dried.

In known plants of the kind described it is usual to promote the evaporation of the solvent by heating the web from the uncoated side, e.g., by contact with a heating element.

In any case it is conventional to remove the solvent vapors by a strong air stream from the evaporation zone. With vapors of combustible liquids, this operation requires the movement of large volumes of air. The proportion of the solvent vapors in the exhausted air must not form an explosive mixture. The large excess of air required renders difficult the recovery of the solvents by a simple condensation and even by absorbents. With inexpensive solvents, such as benzine, acetone, or low alcohols in most cases it appears to be more economical for this reason not to recover the solvent at all and to blow off the mixture of air and solvent vapors into the air. This practice often results in a nuisance to the neighbourhood and sometimes endangers the health of nearby residents.

It is an object of the invention to avoid the above described disadvantages and to enable an economically justified recovery of solvents.

According to the invention, there is provided a plant for recovering a volatile solvent during the drying of a web coated on one side with such volatile solvent serving as a carrier for a material to be deposited on the web upon evaporation of the solvent, the plant comprising a casing having an entry and exit for the passage of the web into and out of the casing, guide means being provided to guide the web in its passage through the casing, a heater being positioned within the casing to heat one face of a web when guided by said guide means, at least one condenser being positioned within the casing to lie opposite the heater facing, spaced from, and juxtaposed with the other face of such web.

The invention will be described more fully hereinafter with reference to the drawing, in which Fig. 1 is a sectional view showing a simple embodiment of the apparatus according to the invention with means for moving the web along a substantially vertical path, Fig. 2 is an enlarged view showing a portion of Fig. 1, Fig. 3 is also a sectional view showing another embodiment of the invention with means for

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moving the web along a horizontal path. Fig. 4 is a broken-away view showing a modification of the apparatus, of figure 3. Fig. 5 shows an embodiment of the invention comprising a rotary heating element, and Fig. 6 is an enlarged view showing the means for receiving and delivering the web in an apparatus as shown in Fig. 5.

In accordance with Fig. 1, a web 1 is moved from a coating plant, now shown in the Figure, in a horizontal direction to a deflecting (i.e. guide) roller 4 in such a manner that the coating 3, which still contains almost all solvent, is on top. The rear side 2 of the web contacts the deflecting roller 4 and the web 1 extends downwardly from the roller 4 at right angles to a further guide roller 6. Between the rollers 4 and 6 the web is guided over a heater 5.

That surface 5*a* of the heater which faces the web is shown in Fig. 1 as being slightly cambered in the direction of travel of the web. Whereas the heating surface 5*a* might alternatively be flat, the web can be guided more exactly in case of a slight curvature.

By suitable measures, the heater 5 is maintained at a temperature which is selected according to the solvent to be removed and by the heat transfer from the heater to the carrier web. Generally, the temperature of the heating surface will be controlled within a range between a temperature just below the boiling point of the most volatile constituent of the application mixture and a temperature just above the boiling point of the high boiling point constituents. Generally, if the carrying webs are relatively thick or have a low thermal conductivity, e.g. paper, a higher temperature of the heating surface will be selected than e.g. with coating of metal foils.

Within the scope of the invention, different temperatures may be provided in different zones of the heating surface. For instance, the upper portion of the heater 5 may be maintained at a lower temperature than the lower portion.

As is shown in Fig. 2 the heater 5 may be heated in known manner by a flowing heating fluid 5*b*, such as hot water. Alternatively, other heat transfer liquids or vapor may be used. Finally, the heater may be heated by electric energy. In case of heating with hot liquids or vapor, the heating fluid is suitably conducted in a countercurrent. With reference to Fig. 1, this means that the heating fluid is introduced into the lower portion of the heater 5 and is withdrawn from the upper portion thereof, near the deflecting roller 4. In this case the temperature will be lower in the upper portion of the heater than in the lower portion and excessively abrupt temperature changes in the coating will be avoided.

The heated zone of the web 1 is directly faced by a juxtaposed condenser 9 through which a cooling liquid 9*b* flows and which causes the solvent vapours escaping from the web to condense on the surface 9*a* of the condenser.

When the web 1 has travelled through the evaporating zone 13 defined by the first heater 5, the web is moved over the preferably heated reversing roller 6, which like the roller 4, is contacted by the rear side of the carrier web 2. When the web has been reversed by roller 6 to move in the opposite direction, the web is conducted upwardly from roller 6 over a second heater 7, which may be designed like the heater 5. It will be of advantage to select for this heater 7 a somewhat higher temperature than that of the heater 5. The heater 7 is faced by a condenser 10, which is designed like the condenser 9.

After having left the evaporating space defined between the heater 7 and the condenser 10, the web is withdrawn around a deflecting roller 8.

It is emphasized that unlike the rollers 4 and 6 the deflecting roller 8 contacts the coating 3. Whereas said coating will be already dry at this point if the apparatus according to the invention is properly adjusted, it is recommended to provide this roller 8 with a cover layer which prevents the coating of the web from sticking to the roller even under the most adverse circumstances. This cover layer may consist, e.g. of silicone rubber, polytetrafluoroethylene or similar material.

The heaters 5 and 7, the condensers 9 and 10 and the reversing roller 6 are jointly enclosed by a casing 11, which is provided at its upper wall with apertures for passing the web through the wall casing. The axes of the deflecting rollers 4 and 8 are desirably disposed approximately in the plane of the upper wall of the casing. This arrangement of the rollers enables the space within the casing to be sealed to a large extent from the environment. This will be explained hereinafter.

In operation, the layer 3 is first heated by its contact with the heater 5 so that the solvent gradualy evaporates from the layer. The vapour 13 fills the space between the web and the condenser 9. Because the condenser is maintained at a temperature below the dew point of the respective distributing fluid, the vapor will condense on the surface of the condenser and a liquid film 14 of pure solvent will be formed, which film, as shown in Fig. 2, flows down that surface of the condenser facing the web.

Whereas the distance *s* of the condenser from the coated surface should be minimized, it can hardly fall below about 5 millilmetres. This lower limit is imposed by the following circumstances:

In any event there has to be avoided that irregularities of the coating, wrinkles in the web or the like cause the coating to contact the opposite surface 9a of the condenser 9. Depending on the nature of the distributing fluid used for coating, the condensate will to a greater or lesser extent wet the cooling surface. Particularly if the wetting is poor, the liquid may condense on the condenser in the form of more or less spherical, discrete droplets. For this reason, the distance of the condenser from the coated web must be so large that any liquid droplets to be expected will not contact the web. Because the condensate flows down on the condenser, the resulting liquid film 14 may increase in thickness towards the lower end of the condenser. This fact must also be taken into account in selecting the distance of the condenser from the web.

For this reason it will be desirable to adjustably mount the condensers within the enclosure, as is indicated, e.g., by the screws 12 in Fig. 1.

Similar remarks are applicable to the adjustment of the distance of the condenser 10 from the heater 7. The condensate which has been collected by the condensers 9 and 10 flows down and leaves the casing by a drainpipe 15.

The space between the two heaters 5 and 7 affords no advantage either for the evaporation or for the condensation but is a non-useful space. It has been found that an excessively large non-useful or dead space renders an adjustment of steady-state drying conditions more difficult because the solvent vapors tend first to fill that dead space before a uniform condensation begins and solvent drains through the drainpipe 15 at the rate at which solvent enters the plant with the coating through the entrance. For this reason, the dead space is suitably reduced in size by the provision of filler members 17.

Because the vapors of almost all distributing fluids in question are heavier than air, the solvent vapors remain stagnant in the enclosed space in the casing and displace the air in the arrangement shown. For this reason, the mere fact that the entrance and exit for the web are provided at the top of the casing prevents to a large extent an escape of solvent vapors into the environment. Because the movement of the web imparts movement also to the adjacent gas phase at the roller 4 air is entrained into the evaporating space and solvent vapors are entrained by the moving web into the open. For this reason it is recommended to seal the passages for the web in the casing walls as far as possible. In this connection it might appear obvious to move the web into the housing and out of the same through narrow slots only. It has been found, however, that those portions of the web which move without restraint perform certain movements transversely to their own plane, e.g., fluttering movements, changes in sag in response to a change in tension, and the like, so that an exact control of the web movement as it passes through the housing wall is not ensured. For this reason it is recommended to arrange the deflecting rollers 4, 8 in the plane of the casing 11 so that the web lies firmly on the deflecting roller and does not perform transverse movements.

The heaters and coolers need not be vertically arranged. As is shown in Fig. 3, the invention may also be applied to an arrangement in which the web is moved substantially horizontally through the drying chamber. As in Fig. 1, the drying chamber comprises a space which is enclosed by a casing 31, the passages for the web 1 being again situated at the top of the casing 31. The web path itself is again defined by deflecting rollers (24 and 26). The underside of the casing 31 is partly formed by a condenser 29, which is slightly sloped downwardly from right to left and extends below the horizontal portion of the web. The condensate 14 deposited on the condenser 29 is drained through the drainpipe 15, as in Fig. 1.

The coating on the web 1 is again disposed on the outside as related to the deflecting rollers 24 and 26 so that said rollers as well as the heater 25 disposed above the web contact the uncoated side of the web only.

The drying chamber within the casing is sealed from the outside air by measures described more fully hereinafter. At the entrance, an adjustable bar 33 is provided, which should be moved as closely as possible to the coating. Slight leaks are not significant at this point because the movement of the web tends to prevent an escape of vapors opposite to the direction of travel of the web. At the exit, the seal is effected in that the deflecting roller 26 contacting the rear side of the cooperates with a further deflecting roller 28, which contacts the coated side of the web and is partly wrapped (looped) by the latter. Almost no solvent vapors can escape through the gap between the rollers 26 and 28. Resilient sealing lips 34 are provided on those sides of the rollers 24, 26 and 28 reverse to the web, which lips prevent an escape of solvent at these points.

Because the drying chamber is sealed from the outside air, almost no air can enter the casing so that the mixture is above the upper explosion limit and the risk of an explosion is much reduced. An explosive mixture is present only while starting the plant i.e. before the solvent vapors have displaced the air from the casing. The time in which an explosive mixture may be

present is much reduced by the provision of a filler member 17.

It is apparent from Fig. 3 that the heater is divided into four parts 25*a*, 25*b*, 25*c*, and 25*d*, each of which is provided with bores 35 (identified only at the heaters 25*a* and 25*b*) in which, e.g., electrically heated heating rods are inserted. Alternatively, a heating fluid may be conducted through the bores 35. The division of the heater into a plurality of parts is recommended for adjustment of the temperature most favourable for the actual degree of dryness of the web.

At the end of the drying zone, the temperature may be increased above the boiling point of the solvent so as to ensure complete drying of the coating.

Fig. 4 shows a modification of the condenser for a drying plant as shown in Fig. 3. The condenser is divided into several cooling elements 30*a* to 30*e*. Gaps 32 are provided between the individual cooling elements, which are downwardly inclined towards the gaps. The intermediate cooling elements 30*b*, 30*c* and 30*d* are approximately roof-shaped. The condensate flows over the inclined surfaces shown to the gaps 32 and then through the latter into a funnel-like collecting space and to the drainpipe 15.

It is recommendable to divide the condenser only in the direction of travel of the web, as is shown in Fig. 4, which means that each cooling element extends throughout the width of the web. This arrangement will avoid non-uniform drying of the web and formation of stripes dried to different degrees. Similar remarks are applicable to the arrangement of the heaters 25*a* — 25*d* shown in Fig. 3. The deflecting roller 28 is desirably also provided with a non-stick material, as is the roller 8 in Fig. 1. This will be particularly desirable if a coating of a pressure-sensitive adhesive, e.g. for a self-adherent tape, is contemplated.

The drying and solvent recovery plant shown in Fig. 5 differs from the one described hereinbefore mainly by the use of a rotary heater. The carrier web 1 moves from a supply roll 41 through a coating unit 42, shown here diagrammatically only to a deflecting roller 44, which has substantially the same function as the rollers 4 and 24 in Figs. 1 and 3, respectively, i.e. to ensure an exact guidance of the web where it moves through the casing 51 enclosing the drying chamber. The web then wraps a heated drum 45 with a looping angle of almost 300° and at the end of the circular path around the drum emerges from the enclosed drying chamber around a deflecting roller 48, provided with a non-stick coating. The web may then either be supplied to further treating stations, indicated at 60, with optional interposing of additional deflecting rollers, as indicated at 48*a*, or the web may be directly wound up as indicated at 61. In the lower third of the space enclosed by the casing 51, a condenser 49 is positioned and is shown here as a cooling tub, which extends not only around approximately the lower third of the periphery of the heating drum 45 but also over part of its end face. The casing 51 is provided with a window 52, which permits one to observe the condition of the web immediately before entering into the gap between the drying drum 45 and the condenser 49.

The heating drum 45 may be heated by any desired means. The drum may be heated by a direct supply of steam, by heat transfer oils as well as by electric power.

The solvent expelled from the coating 3 of the web as a result of the supply of heat condenses on the surface of the condenser 49 and flows down along the same and through the drainpipe 15. A siphon trap 16 is suitably provided in the drainpipe 15 to prevent any ingress of air into the drying chamber.

The vaportight passage of the web through the casing 51 will be described in detail with reference to Fig. 6. With its uncoated rear side, the web 1 contacts the roller 44 and is downwardly deflected by the latter through about 45°. The casing 51 is provided with a sealing strip 53 where the web 1 wraps around the roller 44. The strip 53 is secured to a flange of the casing by a screw 53*b*, which extends through an oval aperture 53*a* in the sealing strip 53 so that the latter can be adjusted at right angles to the surface of the web, i.e., radially to the roller 44. The axis of the deflecting roller 44 lies in the plane of one wall of the casing 51, i.e. the upper wall 51*a*, according to Fig. 6. The reverse side of the roller 44 passing through the casing wall may be sealed by a resilient sealing lip 54*a* which slides directly on the surface of the roller 44.

The exit for the web can be sealed more easily since deflecting here is effected over the coated side of the web. Specifically, the coating 3 of the web 1 contacts the deflecting roller 48, which is again provided with a non-stick cover-layer and is wrapped by the web approximately for half of the periphery of the roller. The uncoated rear side of the web may be sealed by means of an elastic sealing lip 54*b*.

Another sealing lip 54*c* is provided on the reverse side of the deflecting roller and like the sealing lip 54*a* slides directly on the surface of the roller 48. In view of the direction of movement of the roller, the sealing lip 54*c* is provided on the inside of the casing 51. As indicated at 55 in Fig. 6,

another sealing may be provided at the bearings and, if required, at the end faces of the rollers 44 and 48.

WHAT WE CLAIM IS:—

1. A plant for recovering a volatile solvent during the drying of a web coated on one side with such volatile solvent serving as a carrier for a material to be deposited on the web upon evaporation of the solvent, the plant comprising a casing having an entry and exit for the passage of the web into and out of the casing, guide means being provided to guide the web in its passage through the casing, a heater being positioned within the casing to heat one face of a web when guided by said guide means, at least one condenser being positioned within the casing to lie opposite the heater, facing, spaced from, and juxtaposed with the other face of such web.

2. A plant according to claim 1, wherein a pair of apertures providing the said entry and exit of the casing is disposed at or adjacent to an uppermost portion of the casing.

3. A plant according to claim 1 or claim 2, wherein the guide means includes one guide member located adjacent the casing entry and another guide member located adjacent the casing exit.

4. A plant according to claim 3, wherein the said guide members comprise rollers the axes of rotation of which are disposed in the plane of a wall of the casing.

5. A plant according to any preceding claim, wherein the heater is stationary and is divided into a plurality of parts, the parts being heatable independantly of each other.

6. A plant according to any preceding claim, wherein a web is provided which is guided by said guide means.

7. A plant according to claim 5 and claim 6, wherein each heater part extends the width of the web.

8. A plant according to any one of claims 1 to 4, or according to claim 6 when dependant on any one of claims 1 to 4, wherein a rotary heater is provided which is disposed to be in contact with the web whereby the peripheral velocity of the heater is equal to the velocity of such web.

9. A plant according to any preceding claim, wherein the condenser is mounted so as to be adjustable as regards its distance from the web.

10. A plant according to claim 9, wherein the condenser is mounted by means of adjustable screws.

11. A plant according to any preceding claim wherein a filler is provided in the casing to occupy a non-useful space within the casing.

12. A plant according to any preceding claim, wherein a lower part of the casing has a drain for condensed solvent.

13. A plant for recovering a volatile solvent during the drying of a web substantially as described with reference to the accompanying drawings.

14. A plant according to claim 1 substantially as described herein.

15. A method of operating a plant according to any preceding claim, including the step of driving the web through the casing with the face of the web which faces the condenser coated with a volatile solvent carrying material to be deposited on the web.

Agents for the Applicants
STANLEY, POPPLEWELL, FRANCIS, & ROSS,
Chartered Patent Agents,
20/21 Tooks Court,
Cursitor Street,
London, EC4A 1LB.

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Sheet 1

FIG.1

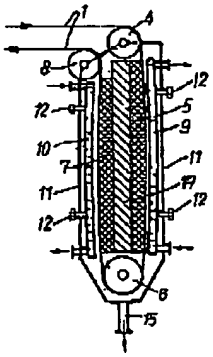


FIG.2

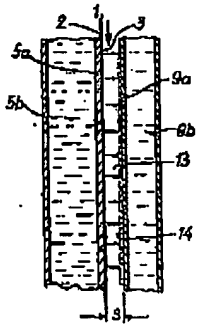


FIG.3

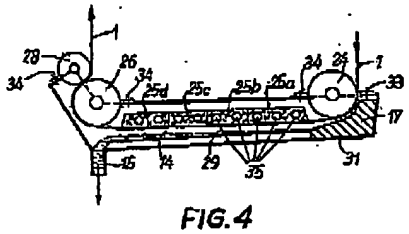
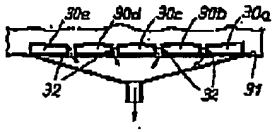


FIG.4



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Sheet 2

FIG.5

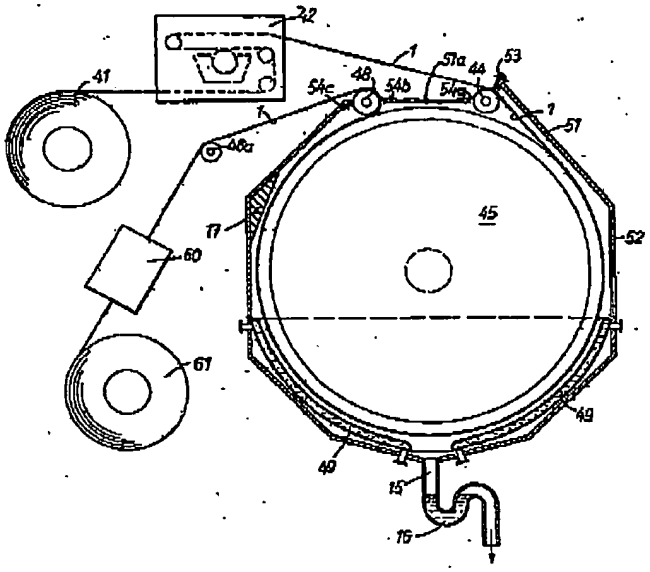

FIG.6